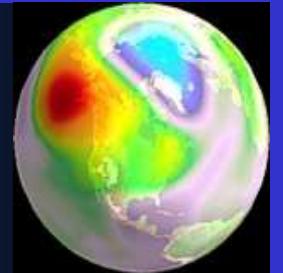




NRL Ozone Assimilation Mini-Workshop



Parameterized Ozone Photochemistry in the NOGAPS-ALPHAGCM

J. McCormack

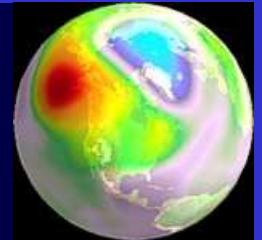
S. Eckermann, L. Coy, D. Allen

Naval Research Laboratory, Washington DC, USA



NOGAPS-ALPHA

NOGAPSwithAdvancedLevelPhysics-HighAltitude

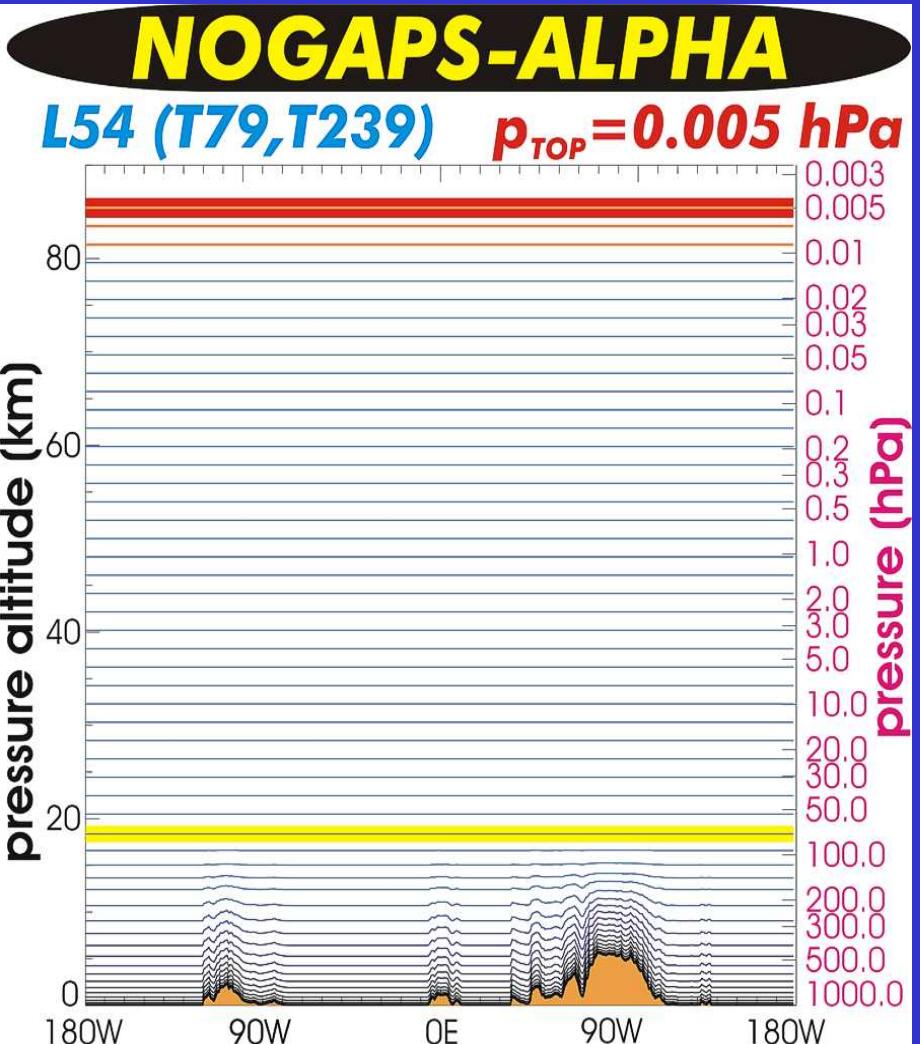


Motivations for Prognostic Ozone in NOGAPS-ALPHA

- Improved satellite radiance assimilation
- Prognostic ozone feeds into model radiative heating calcs
à Improved forecasts

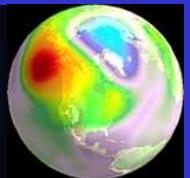
Model Configuration

- Model top at 0.005 hPa ($z \sim 85\text{ km}$)
- T79 & T239 spectral truncation
- CLIRAD radiation scheme currently uses 2DO 3
- New 3D prognostic ozone features
 - spectral transport
 - GMAO GEOS4 Initialization
 - Linearized O₃ photochemistry





Linearized O₃ Photochemistry Scheme for NOGAPS-ALPHA



If we assume $\frac{df}{dt} = (P-L)[f, T, c_{O_3}]$, we can obtain a Taylor series expansion about a mean state (f_o, T_o, c_o) after Cariolle and Déqué [1986] (“CD86”) and McLinden et al .[2000] (“LINOZ”):

$$\frac{df}{dt} = (P - L)^o + \frac{\partial(P - L)}{\partial f} \Big|_o (f - f^o) + \frac{\partial(P - L)}{\partial T} \Big|_o (T - T^o) + \frac{\partial(P - L)}{\partial c_{O_3}} \Big|_o (c - c_{O_3}^o)$$

1

2

3

4

NOGAPS Fields

- 1. Ozone Mixing Ratio, f
- 2. Temperature, T
- 3. Column O₃, c

Photochemistry Parameters (y,z,t LookupTables)

- 1. Mean/Equilibrium Production-Loss $(P-L)_o$
- 2. Photochemical Relaxation Timescale $\tau = -[d(P-L)/df]_o^{-1}$
- 3. Temperature Perturbation Coefficient $[d(P-L)/dT]_o$
- 4. Overhead Column O₃ Perturbation Coefficient $[d(P-L)/dc]_o$

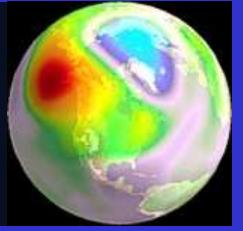
Climatological Fields

- 1. Ozone $f_o(y, z, t)$
- 2. Temperature $T_o(y, z, t)$
- 3. Column O₃ $c_{O_3}(y, z, t)$

NOGAPS-ALPHAP prognostic O₃ can use photochemistry parameters of either CD86(ECMWF), LINOZ, NRL CHEM2D, or Goddard(NCEP) à inter-comparison of the 4 different photochemistry schemes



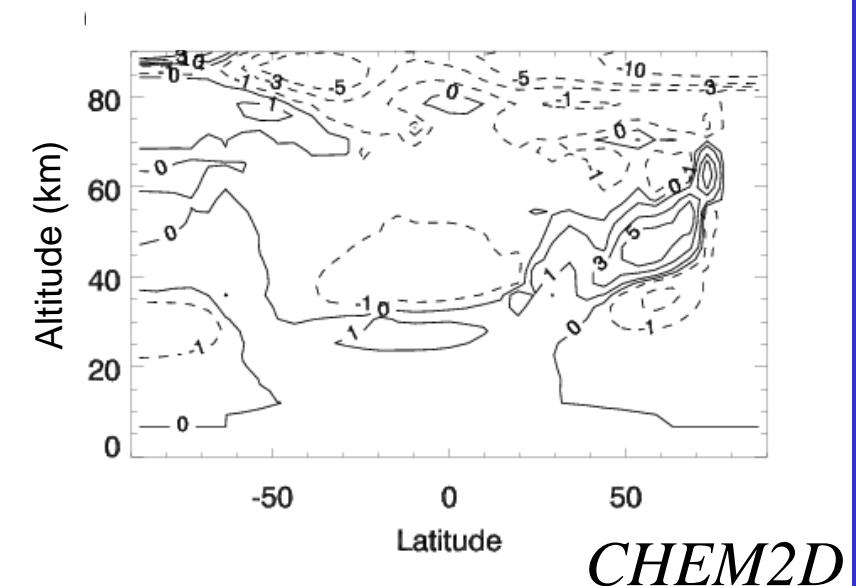
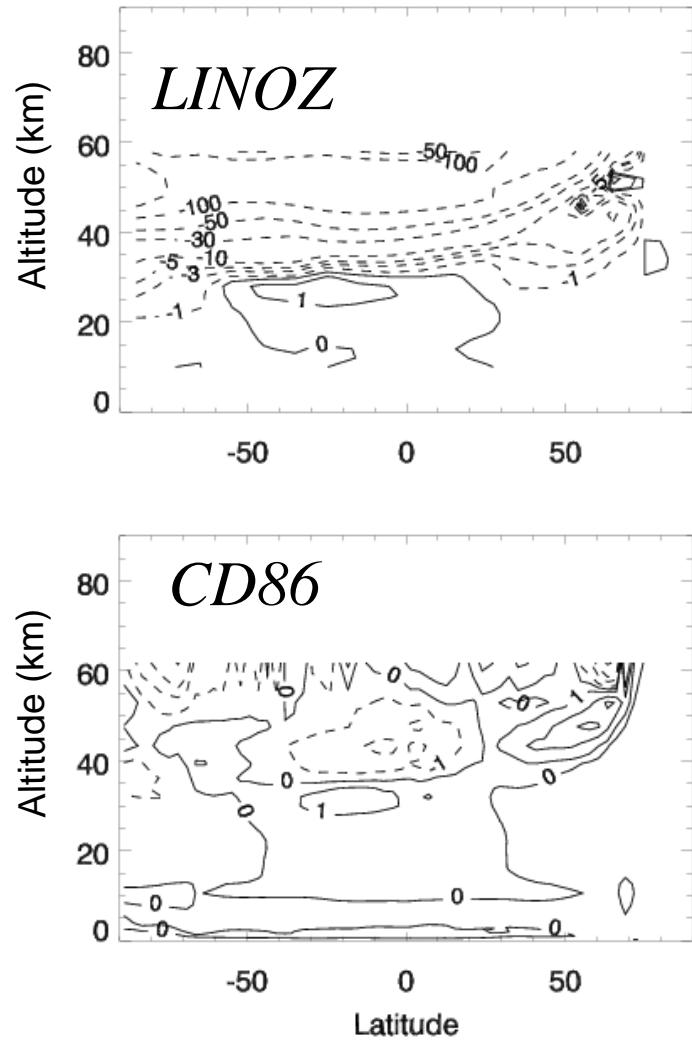
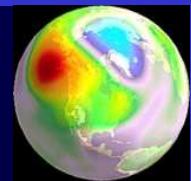
O₃ photochemistry scheme tested in NOGAPS-ALPHA



	1. $P-L$ (ppmv/s)	2. $d(P-L)$ df (s^{-1})	3. $d(P-L)$ dT (ppmv/K)	4. $d(P-L)$ dc_{O_3} (ppmv/DU)	5. PSC effects
CD86 ($Z_{top} \sim 61\text{km}$)	yes	yes	yes	yes	yes (Cl loading)
LINOZ ($Z_{top} \sim 58\text{km}$)	yes	yes	yes	yes	no
CHEM2DV0 ($Z_{top} \sim 85\text{km}$)	yes	yes	preliminary (v1.0)	future work?	testing “cold tracer”
GSFC/NCEP ($Z_{top} \sim 60\text{km}$)	no	yes	no	no	no



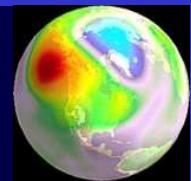
Term1: O_3 (P-L)inppmv/month



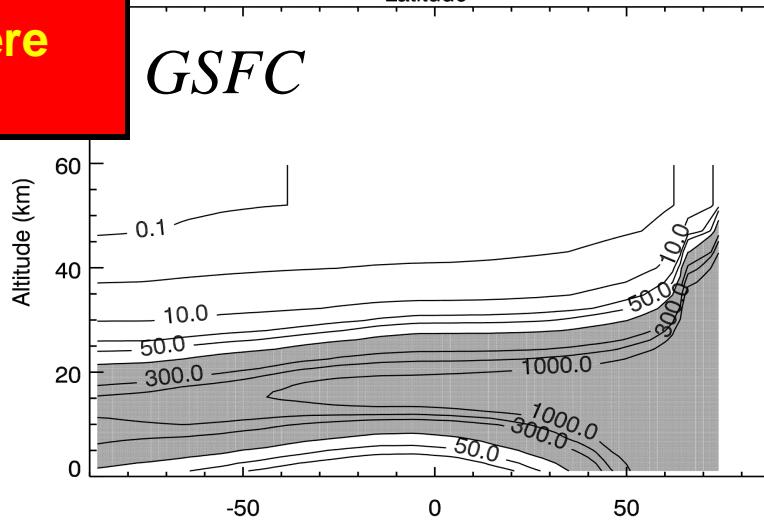
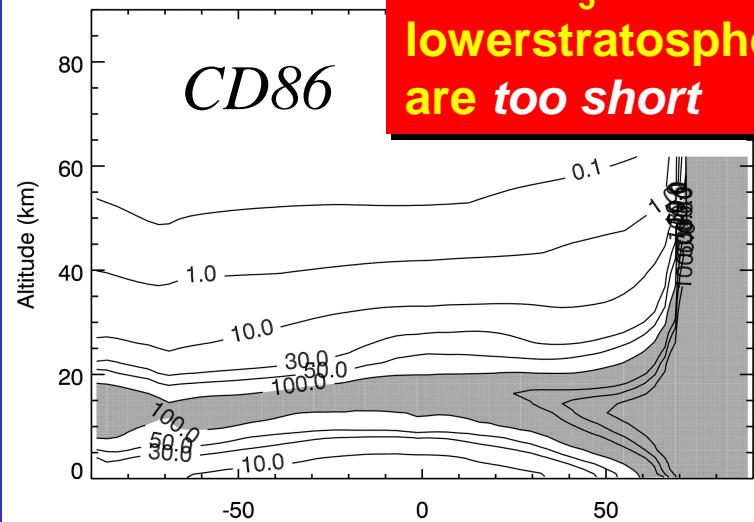
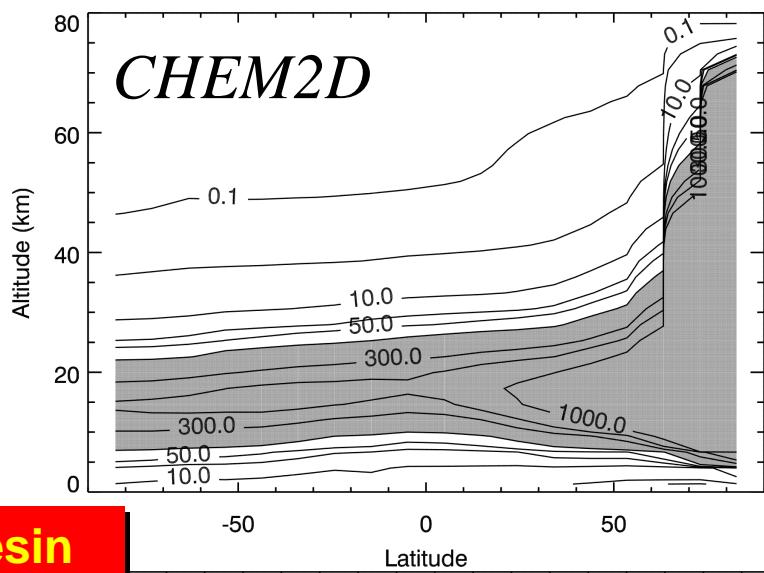
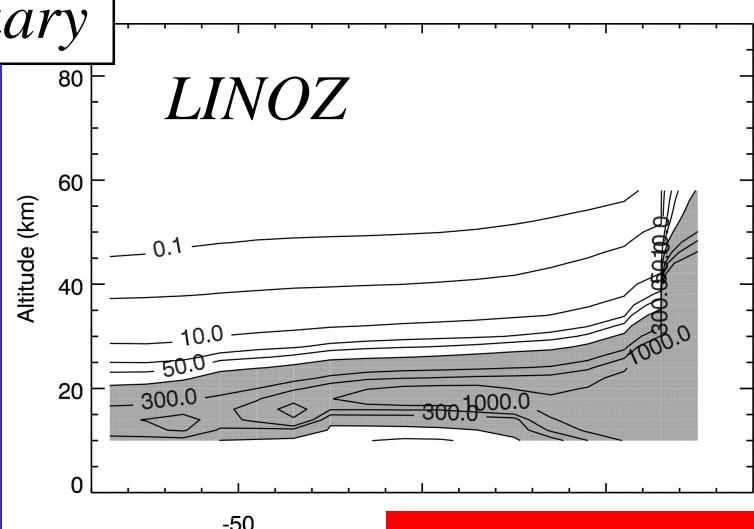
**LINOZO₃ (P-L)above10hPa
yields large low ozone bias**



Term2: O_3 Relaxation Time(Days)



January





SAGE III Ozone Loss and Validation Experiment (SOLVE2 Jan- Feb 2003)



BRITISH ATMOSPHERIC
DATA CENTRE



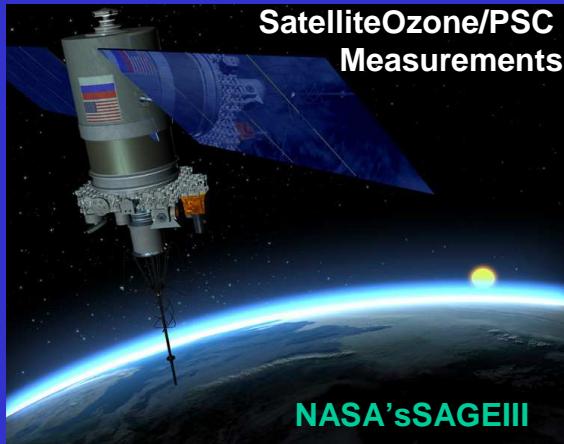
European Centre
for Medium-Range
Weather Forecasts



NAVAL RESEARCH
LABORATORY



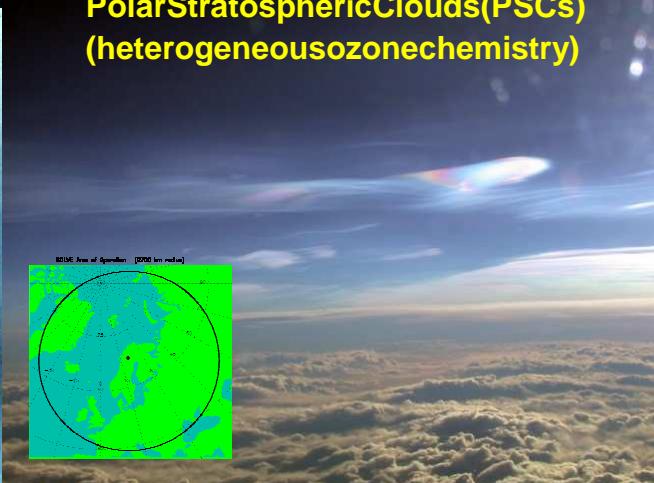
Naval Research Laboratory
MWFM
Mountain Wave Forecast Model



NASA's SAGE III

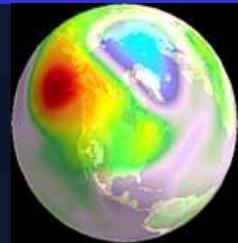


Polar Stratospheric Clouds (PSCs)
(heterogeneous ozone chemistry)

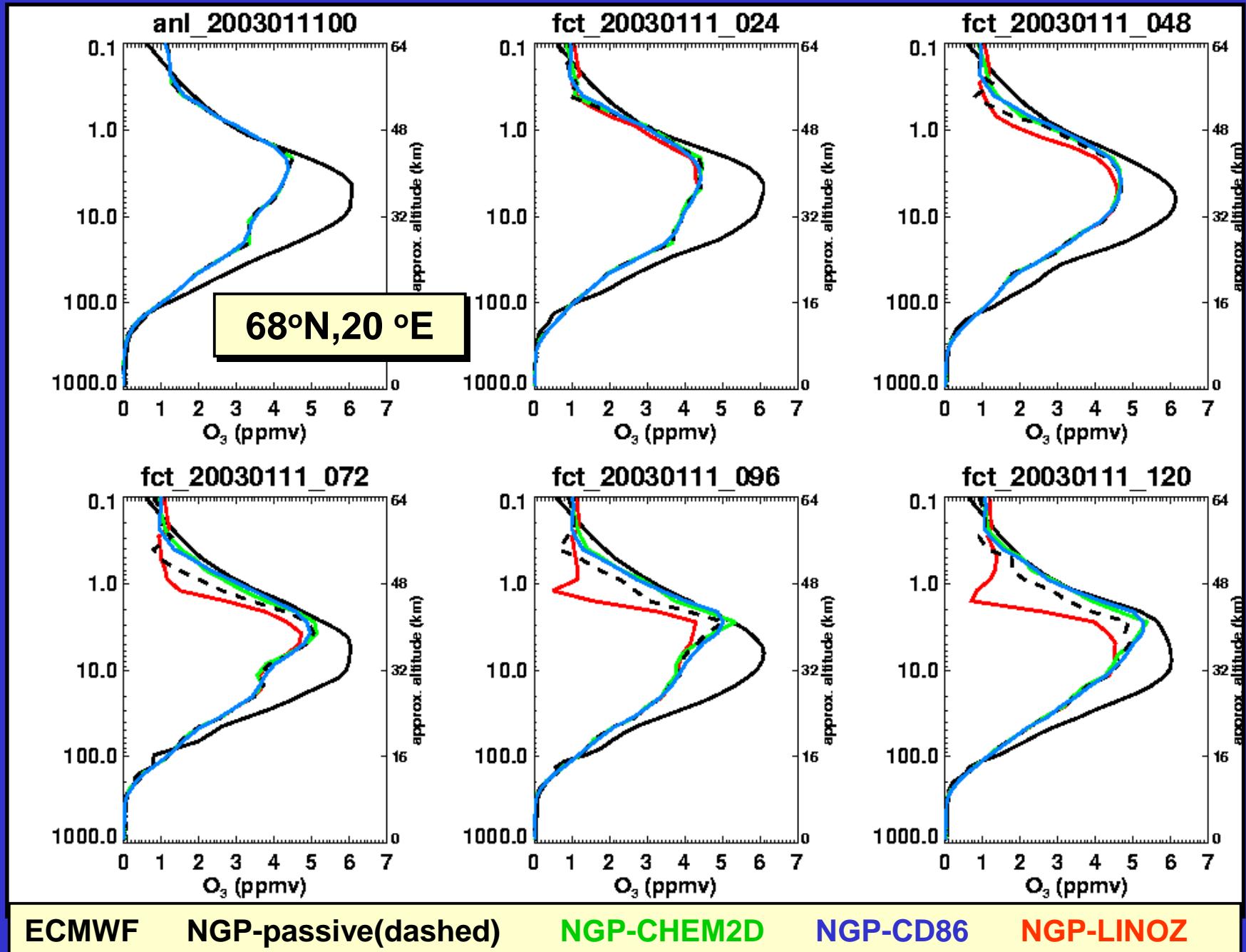


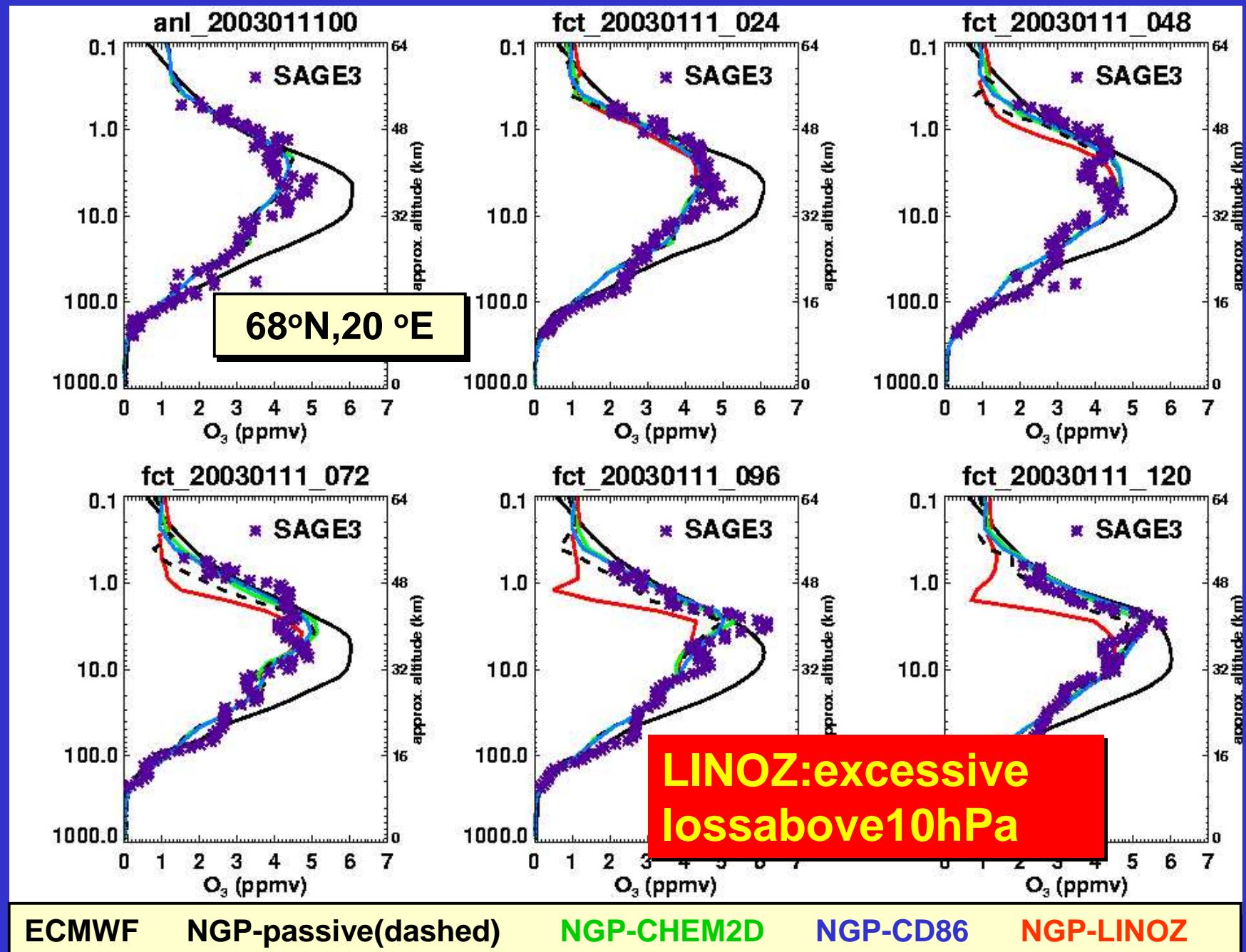


NOGAPS Hindcasts: SOLVE2



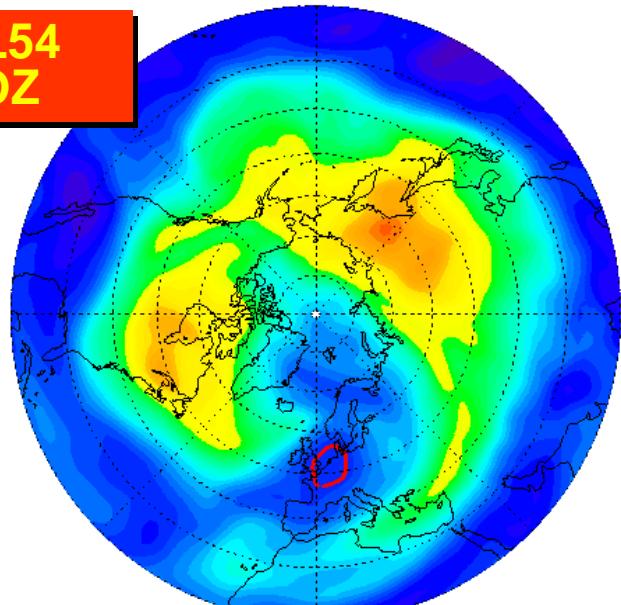
- SOLVE2 provided our first opportunity to test new NOGAPS-ALPHA3-DO₃ initialization, transport & photochemistry.
- We compared results from 5-day hindcasts of interesting ozone events in Jan 2003 using CD86, LINOZ, and CHEM2DV0, initialized with GMAO or ECMWFIFS3D assimilated ozone fields
- Overall the best results were obtained with the CHEM2DV0 scheme, despite the fact it has no temperature or column ozone terms
- For more details see McCormack et al., *Atmos. Chem. Phys.*, 4, 2401-2423, 2004 .





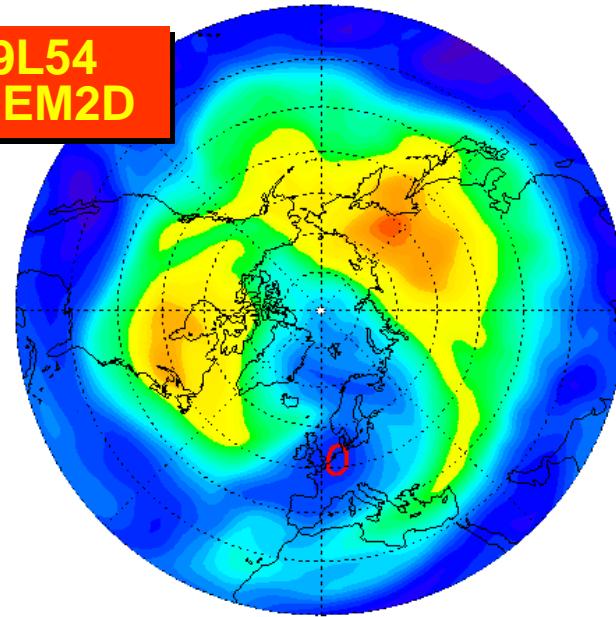
NOGAPS- α FCT TOTOZ : 2003011100 : t = 000096 h

T79L54
LINOZ



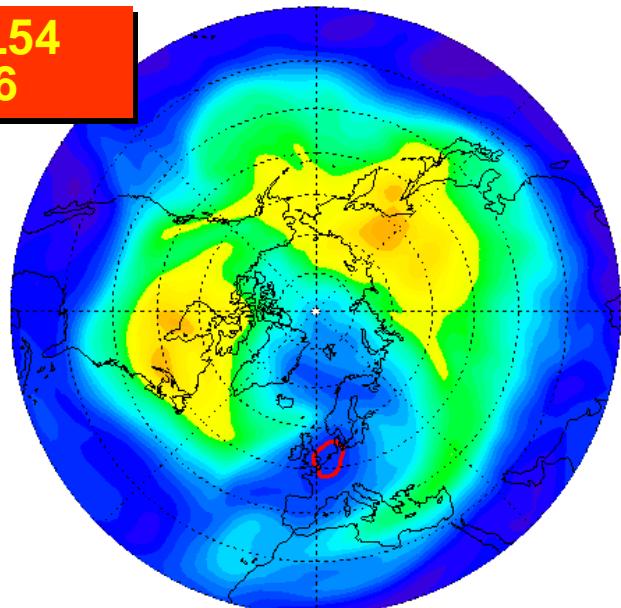
NOGAPS- α FCT TOTOZ : 2003011100 : t = 000096 h

T79L54
CHEM2D



NOGAPS- α FCT TOTOZ : 2003011100 : t = 000096 h

T79L54
CD86

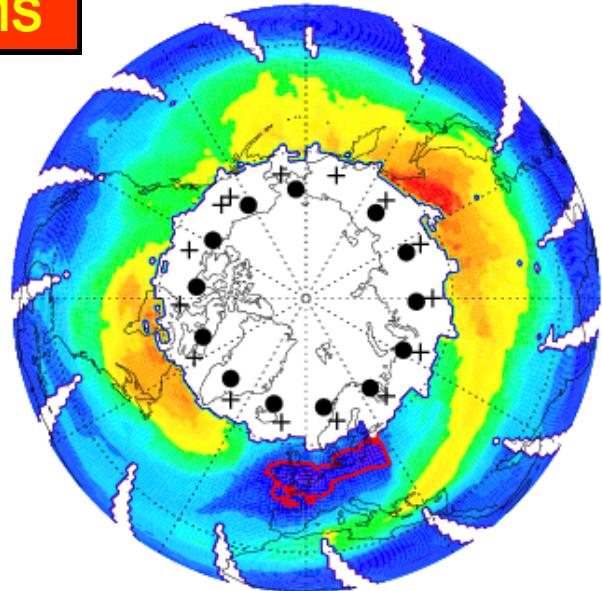


TOTALOZONE:15Jan0Z

All 3 different photochemistry schemes yield similar results for total ozone. In the lower stratosphere, the very short CD86 O₃ relaxation time ($\tau = [d(P-L)/df]_0^{-1}$) smooths out zonal structure at mid-latitudes .

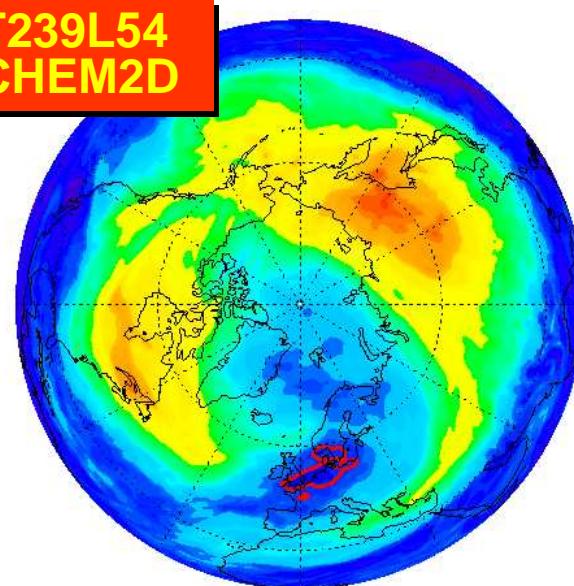
EPTOMS

EPTOMS : 20030114

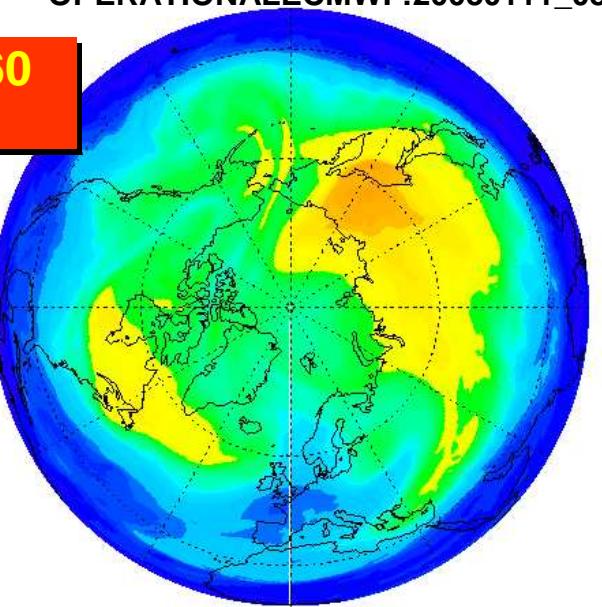


NOGAPS-ALPHA:20030111_84

**T239L54
CHEM2D**



**T511L60
CD86**

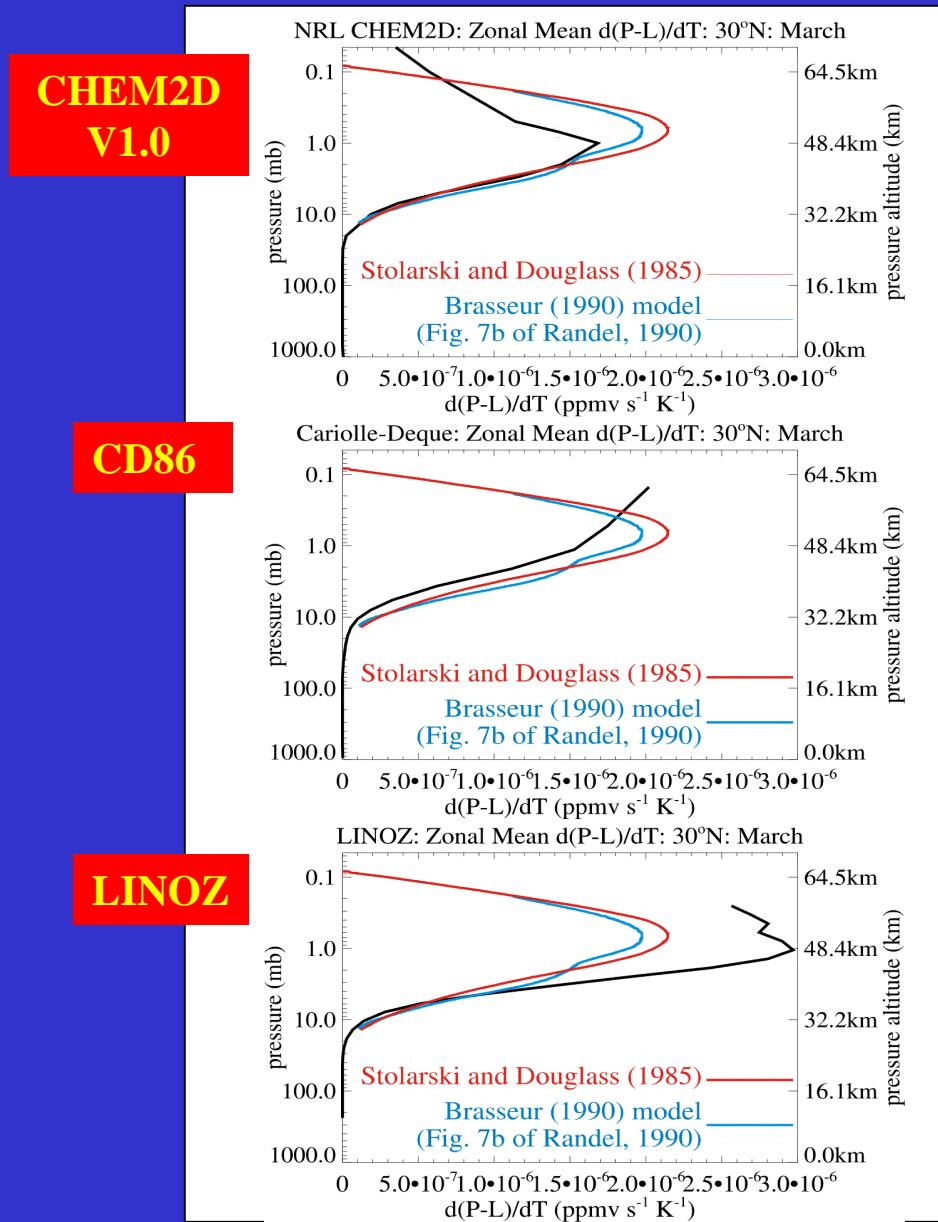


- NASA EPTOMS observes an ozone "mini-hole" feature over Western Europe on 14 Jan 2003

- Operational ECMWF T511L60 ozone forecasts issued on 11 Jan under-predicts the mini-hole.

- NOGAPS-ALPHA T239L54 hindcast initialized 11 Jan with GMAOO₃ and using V0 CHEM2D scheme captures mini-hole feature .

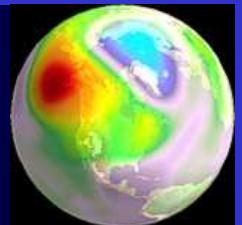
Including temperature dependence in CHEM2D scheme: “V1.0”



$d(P-L)/dT$ for March 30 °N



Summary



	1. $P-L$	2.d($P-L$) df	3.d($P-L$) dT	4.d($P-L$) dc_{O_3}
CD86 ($z_{top} \sim 61km$)	ok	x (τ too short)	ok	ok
LINOZ ($z_{top} \sim 58km$)	x (too much loss above 10hPa)	ok	x (too large above 1hPa)	ok
CHEM2DV0 ($z_{top} \sim 85km$)	ok	ok	ü preliminary (v1.0)	?
GSFC/NCEP ($z_{top} \sim 60km$)	-	ok	-	-